

WHAT IS CLAIMED IS:

1. A microphone device which detects a target sound coming from a direction of the target sound, comprising:

5 a signal generating section for generating a main signal indicative of a result obtained through detection with a sensitivity in the direction of the target sound and a noise reference signal indicative of a result obtained through detection with a sensitivity higher in another direction than in the direction
10 of the target sound;

 a determining section for determining whether a level ratio indicative of a ratio of a level of the main signal to the noise reference signal generated by the signal generating section is larger than a predetermined value;

15 an adaptive filter section for generating a signal indicative of a signal component of the target sound included in the noise reference signal generated by the signal generating section by performing, by an adaptive filter included in the adaptive filter section, a filtering process on the main signal
20 generated by the signal generating section, and for learning a filter coefficient only when the determining section determines that the level ratio is larger than the predetermined value;

 a subtracting section for subtracting the signal generated by the adaptive filter section from the noise reference
25 signal generated by the signal generating section; and

a noise suppressing section for suppressing a signal component of noise included in the main signal by using the main signal and the noise reference signal after subtraction by the subtracting section.

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2. The microphone device according to claim 1, wherein the signal generating section includes:

a first microphone unit being placed so that a main axis of directivity is oriented to the direction of the target
10 sound; and

a second microphone unit being placed so that a minimum sensitivity axis of directivity is oriented to the direction of the target sound.

15 3. The microphone device according to claim 1, further comprising

a signal delaying section, being provided between an output end of the noise reference signal in the signal generating section and the subtracting section, for delaying the noise
20 reference signal so as to satisfy conditions of convergence of the adaptive filter of the adaptive filter section.

4. The microphone device according to claim 1, wherein the predetermined value is changeable.

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5. The microphone device according to claim 1, wherein the signal generating section includes:

a first microphone unit;

a second microphone unit having a characteristic
5 identical to a characteristic of the first microphone unit;

a delaying section for outputting a signal output from the first microphone unit as being delayed by a predetermined delay amount;

an amplifying section for amplifying the signal
10 output from the delay section;

a first subtracting section for subtracting the signal amplified by the amplifying section from a signal output from the second microphone unit to generate the main signal; and

a second subtracting section for subtracting the
15 signal output from the delaying section from the signal output from the second microphone unit to generate the noise reference signal, wherein

the predetermined delay amount is set so that the noise reference signal includes components of a sound coming from a
20 direction other than the direction of the target sound more than components of the target sound, and

an amplification factor in the amplifying section is set so as to cause a difference in a sensitivity to the target sound between the main signal and the noise reference signal.

6. The microphone device according to claim 5, further comprising

a setting section for changing the predetermined delay amount used in the delay section.

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7. The microphone device according to claim 1, wherein the signal generating section includes:

a first microphone unit;

10 a second microphone unit having a characteristic identical to a characteristic of the first microphone unit; and

a combining section for generating, based on signals output from the first and second microphone unit, the main signal with the sensitivity in the direction of the target sound, and generating a noise signal with minimum sensitivity in the direction
15 of the target sound.

8. The microphone device according to claim 1, wherein the signal generating section includes:

a first microphone unit;

20 a second microphone unit being placed so that a main axis of directivity is oriented to a direction which is different from a main axis of directivity of the first microphone unit;

a signal adding section for adding a first signal output from the first microphone unit and a second signal output
25 from the second microphone unit to generate the main signal; and

a signal subtracting section for subtracting a third signal, which is either one of the first signal and the second signal, from a fourth signal, which is either one of the first signal and the second signal but other than the third signal, to
5 generate the noise reference signal.

9. The microphone device according to claim 1, wherein the signal generating section includes:

a first microphone unit;
10 a second microphone unit having a characteristic identical to a characteristic of the first microphone unit;
a stereo signal generating section for generating, based on the first and second microphone units, a stereo signal formed by a right channel signal and a left channel signal;
15 an inverse combining section for generating, based on the stereo signal, signals output from the first and second microphone units; and
a combining section for generating the main signal and the noise reference signal based on the signals generated by
20 the inverse combining section.

10. The microphone device according to claim 1, wherein the signal generating section includes:

a first microphone unit;
25 a second microphone unit having a characteristic

identical to a characteristic of the first microphone unit;

a stereo signal generating section for generating, based on the first and second microphone units, a stereo signal formed by a right channel signal and a left channel signal;

5 a signal adding section for adding the right channel signal and the left channel signal to generate the main signal; and

a signal subtracting section for subtracting a first signal, which is either one of the right channel signal and the
10 left channel signal, from a second signal, which is either one of the right channel signal and the left channel signal but other than the first signal, to generate the noise reference signal.

11. The microphone device according to claim 1, further
15 comprising:

a reflection information calculating section for calculating, based on the filter coefficient of the adaptive filter section, information about a difference in arrival time between a direct wave of the target sound and a reflected wave of the target
20 sound; and

a reflection correcting section for correcting, based on the information calculated by the reflection information calculating section, distortion in a frequency characteristic of the main signal caused by the reflected wave, wherein

25 the noise suppressing section suppresses the signal

component of the noise included in the main signal by using the main signal corrected by the reflection correcting section and the noise reference signal after subtraction by the subtracting section.

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12. The microphone device according to claim 1, wherein the noise suppressing section includes:

a time-variant coefficient filter section for causing the main signal to be subjected to a filtering process at a noise suppression filter included in the time-variant coefficient filter section; and

a noise suppression filter coefficient calculating section for calculating, based on the main signal and the noise reference signal after subtraction by the subtracting section, a filter coefficient of the noise suppression filter for suppressing the signal component of the noise included in the main signal, wherein

the filtering process reflects the filter coefficient calculated by the noise suppression filter coefficient calculating section.

13. The microphone device according to claim 12, wherein

the noise suppression filter coefficient calculating section includes:

a first frequency analyzing section for calculating
a power spectrum of the main signal:

a second frequency analyzing section for calculating
a power spectrum of the noise reference signal after subtraction
5 by the subtracting section;

a power spectrum ratio calculating section for
calculating a time average of a power spectrum ratio between the
power spectrum calculated by the first frequency analyzing section
and the power spectrum calculated by the second frequency analyzing
10 section only when the determining section determines that the level
ratio is smaller than the predetermined value;

a multiplying section for multiplying the time
average of the power spectrum ratio calculated by the power spectrum
ratio calculating section by the power spectrum calculated by the
15 second frequency analyzing section; and

a coefficient calculating section for calculating
the filter coefficient of the noise suppression filter based on
the power spectrum calculated by the first frequency analyzing
section and the multiplication result of the multiplying section.

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14. A microphone device which detects a target sound
coming from a direction of the target sound, comprising:

a signal generating section for generating a main signal
indicative of a result obtained through detection with a
25 sensitivity in the direction of the target sound and a noise

reference signal indicative of a result obtained through detection with a sensitivity higher in another direction than in the direction of the target sound;

5 a determining section for determining whether a level ratio indicative of a ratio of a level of the main signal to the noise reference signal generated by the signal generating section is larger than a predetermined value;

10 an adaptive filter section for generating a signal indicative of a signal component of the target sound included in the noise reference signal generated by the signal generating section by subjecting the main signal generated by the signal generating section to a filtering process at an adaptive filter included in the adaptive filter section, and for learning a filter coefficient only when the determining section determines that the level ratio is larger than the predetermined value;

a subtracting section for subtracting the signal generated by the adaptive filter section from the noise reference signal generated by the signal generating section;

20 a reflection information calculating section for calculating information about a difference in arrival time between a direct wave of the target sound and a reflected wave of the target sound; and

a reflection correcting section for correcting, based on the information calculated by the reflection information calculating section, distortion in a frequency characteristic of

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the main signal caused by the reflected wave.

15. The microphone device according to claim 14,
wherein

5 the signal generating section includes:

a first microphone unit being placed so that a main
axis of directivity is oriented to the direction of the target
sound; and

a second microphone unit being placed so that a minimum
10 sensitivity axis of directivity is oriented to the direction of
the target sound.

16. The microphone device according to claim 14,
further comprising

15 a signal delay section, being provided between an output
end of the noise reference signal in the signal generating section
and the subtracting section, for delaying the noise reference
signal so as to satisfy conditions of convergence of the adaptive
filter of the adaptive filter section.

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17. The microphone device according to claim 14,
wherein

the predetermined value is changeable.

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18. The microphone device according to claim 14,

wherein

the signal generating section includes:

a first microphone unit;

a second microphone unit having a characteristic
5 identical to a characteristic of the first microphone unit;

a delaying section for outputting a signal output
from the first microphone unit as being delayed by a predetermined
delay amount;

an amplifying section for amplifying the signal
10 output from the delay section;

a first subtracting section for subtracting the
signal amplified by the amplifying section from a signal output
from the second microphone unit to generate the main signal; and

a second subtracting section for subtracting the
15 signal output from the delaying section from the signal output
from the second microphone unit to generate the noise reference
signal, wherein

the predetermined delay amount is set so that the noise
reference signal includes components of a sound coming from a
20 direction other than the direction of the target sound more than
components of the target sound, and

an amplification factor in the amplifying section is
set so as to cause a difference in a sensitivity to the target
sound between the main signal and the noise reference signal.

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19. The microphone device according to claim 18,
further comprising

a setting section for changing the predetermined delay
amount used in the delay section.

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20. The microphone device according to claim 14,
wherein

the signal generating section includes:

a first microphone unit;

10 a second microphone unit having a characteristic
identical to a characteristic of the first microphone unit; and

a combining section for generating, based on signals
output from the first and second microphone unit, the main signal
with the sensitivity in the direction of the target sound, and
15 generating a noise signal with minimum sensitivity in the direction
of the target sound.

21. The microphone device according to claim 14,
wherein

20 the signal generating section includes:

a first microphone unit;

a second microphone unit being placed so that a main
axis of directivity is oriented to a direction which is different
from a main axis of directivity of the first microphone unit;

25 a signal adding section for adding a first signal

output from the first microphone unit and a second signal output from the second microphone unit to generate the main signal; and
a signal subtracting section for subtracting a third signal, which is either one of the first signal and the second
5 signal, from a fourth signal, which is either one of the first signal and the second signal but other than the third signal, to generate a noise reference signal.

22. The microphone device according to claim 14,
10 wherein

the signal generating section includes:

a first microphone unit;

a second microphone unit having a characteristic identical to a characteristic of the first microphone unit;

15 a stereo signal generating section for generating, based on the first and second microphone units, a stereo signal formed by a right channel signal and a left channel signal;

an inverse combining section for generating, based on the stereo signal, signals output from the first and second
20 microphone units; and

a combining section for generating the main signal and the noise reference signal based on the signals generated by the inverse combining section.

25 23. The microphone device according to claim 14,

wherein

the signal generating section includes:

a first microphone unit;

a second microphone unit having a characteristic
5 identical to a characteristic of the first microphone unit;

a stereo signal generating section for generating,
based on the first and second microphone units, a stereo signal
formed by a right channel signal and a left channel signal;

a signal adding section for adding the right channel
10 signal and the left channel signal to generate a main signal; and

a signal subtracting section for subtracting a first
signal, which is either one of the right channel signal and the
left channel signal, from a second signal, which is either one
of the right channel signal and the left channel signal but other
15 than the first signal, to generate a noise reference signal.

24. A microphone device which detects a target sound
coming from a direction of the target sound, comprising:

a first microphone unit;

20 a second microphone unit being placed so that a main
axis of directivity is oriented to a direction which is different
from a main axis of directivity of the first microphone unit;

a signal adding section for adding a first signal output
from the first microphone unit and a second signal output from
25 the second microphone unit to generate a main signal;

a signal subtracting section for subtracting a third signal, which is either one of the first signal and the second signal, from a fourth signal, which is either one of the first signal and the second signal but other than the third signal, to
5 generate a noise reference signal; and

a noise suppressing section for suppressing a signal component of noise included in the main signal by using the main signal and the noise reference signal.

10 25. A microphone device which detects a target sound coming from a direction of the target sound, comprising:

a first microphone unit;

a second microphone unit having a characteristic identical to a characteristic of the first microphone unit;

15 a stereo signal generating section for generating, based on the first and second microphone units, a stereo signal formed by a right channel signal and a left channel signal;

an inverse combining section for generating, based on the stereo signal, signals to be output from the first and second
20 microphone units;

a combining section for generating, based on the signals generated by the inverse combining section, a main signal indicative of a result obtained through detection with a sensitivity in the direction of the target sound and a noise
25 reference signal indicative of a result obtained through detection

with a sensitivity higher in another direction than in the direction of the target sound; and

a noise suppressing section for suppressing a signal component of noise included in the main signal by using the main
5 signal and the noise reference signal.

26. A microphone device which detects a target sound coming from a direction of the target sound, comprising:

a first microphone unit;

10 a second microphone unit having a characteristic identical to a characteristic of the first microphone unit;

a stereo signal generating section for generating, based on the first and second microphone units, a stereo signal formed by a right channel signal and a left channel signal;

15 a signal adding section for adding the right channel signal and the left channel signal of the stereo signal to generate a main signal;

a signal subtracting section for subtracting a first signal, which is either one of the right channel signal and the
20 left channel signal, from a second signal, which is either one of the right channel signal and the left channel signal but other than the first signal, to generate a noise reference signal; and

a noise suppressing section for suppressing a signal component of noise included in the main signal by using the main
25 signal and the noise reference signal.

27. An audio player, comprising:

an audio recording section for recording audio signals of channels of at least two types;

5 a signal generating section for generating, based on the audio signals recorded on the audio recording section, a main signal indicative of a result obtained through detection with a sensitivity in the direction of the target sound and a noise reference signal indicative of a result obtained through detection
10 with a sensitivity higher in another direction than in the direction of the target sound;

 a determining section for determining whether a level ratio indicative of a ratio of a level of the main signal to the noise reference signal generated by the signal generating section
15 is larger than a predetermined value;

 an adaptive filter section for generating a signal indicative of a signal component of the target sound included in the noise reference signal generated by the signal generating section by performing, by an adaptive filter included in the
20 adaptive filter section, a filtering process on the main signal generated by the signal generating section, and for learning a filter coefficient only when the determining section determines that the level ratio is larger than the predetermined value;

 a subtracting section for subtracting the signal
25 generated by the adaptive filter section from the noise reference

signal generated by the signal generating section;

a noise suppressing section for suppressing a signal component of noise included in the main signal by using the main signal and the noise reference signal after subtraction by the subtracting section; and

a reproducing section for reproducing the main signal with the signal component of the noise being suppressed by the noise suppressing section.

28. The audio player according to claim 27, further comprising:

a video recording section for recording a video signal related to the audio signals recorded on the audio recording section;

a video reproducing section for reproducing the video signal recorded on the video recording section; and

a direction accepting section for accepting from a user an input of a direction in which a sound is to be enhanced; wherein

the signal generating section generates the main signal and the noise reference signal by taking the direction accepted by the direction accepting section as the direction of the target sound.